Shipping Multiple Devicetrees

How to Identify Which DTB is for my Board?

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About

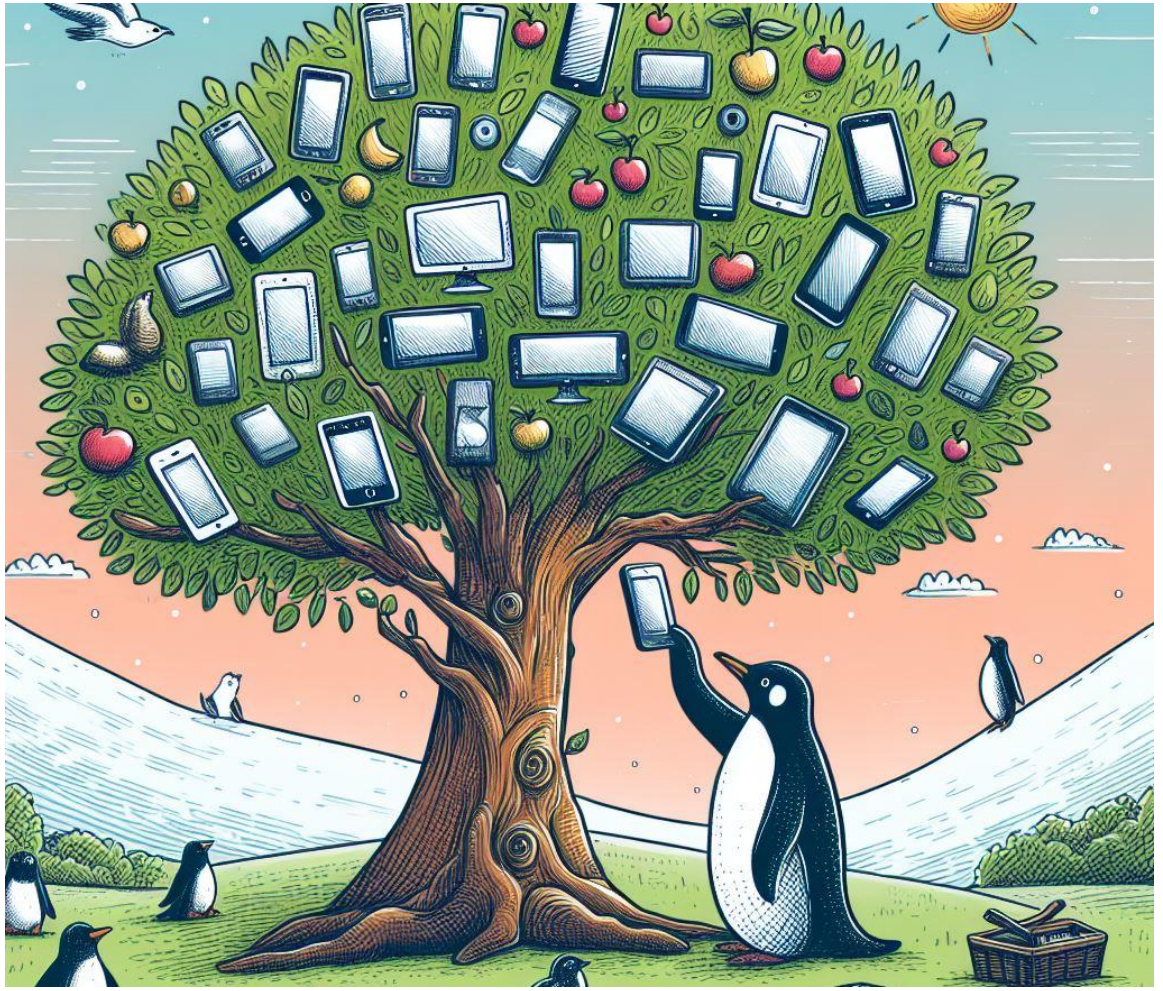
- Linux kernel developer at Qualcomm Innovation Center, Inc. in San Diego, CA
- Some things I've worked on:
  - Gunyah hypervisor
  - Enable Android's Generic Kernel Image (GKI) @ Qualcomm
  - Android's kernel/build

How Devicetrees are Loaded

- Kernel* authors devicetrees
- Bootloader picks up the devicetree and passes to kernel
  - OR: devicetree is appended to kernel
- Kernel doesn't own the bootloader, leaves it to ecosystem to package and pick the DTB it wants

- Ideally, DTB comes from firmware but reality is most boards use kernel-authored devicetree

*kernel = Linux kernel, Zephyr, FreeBSD, more



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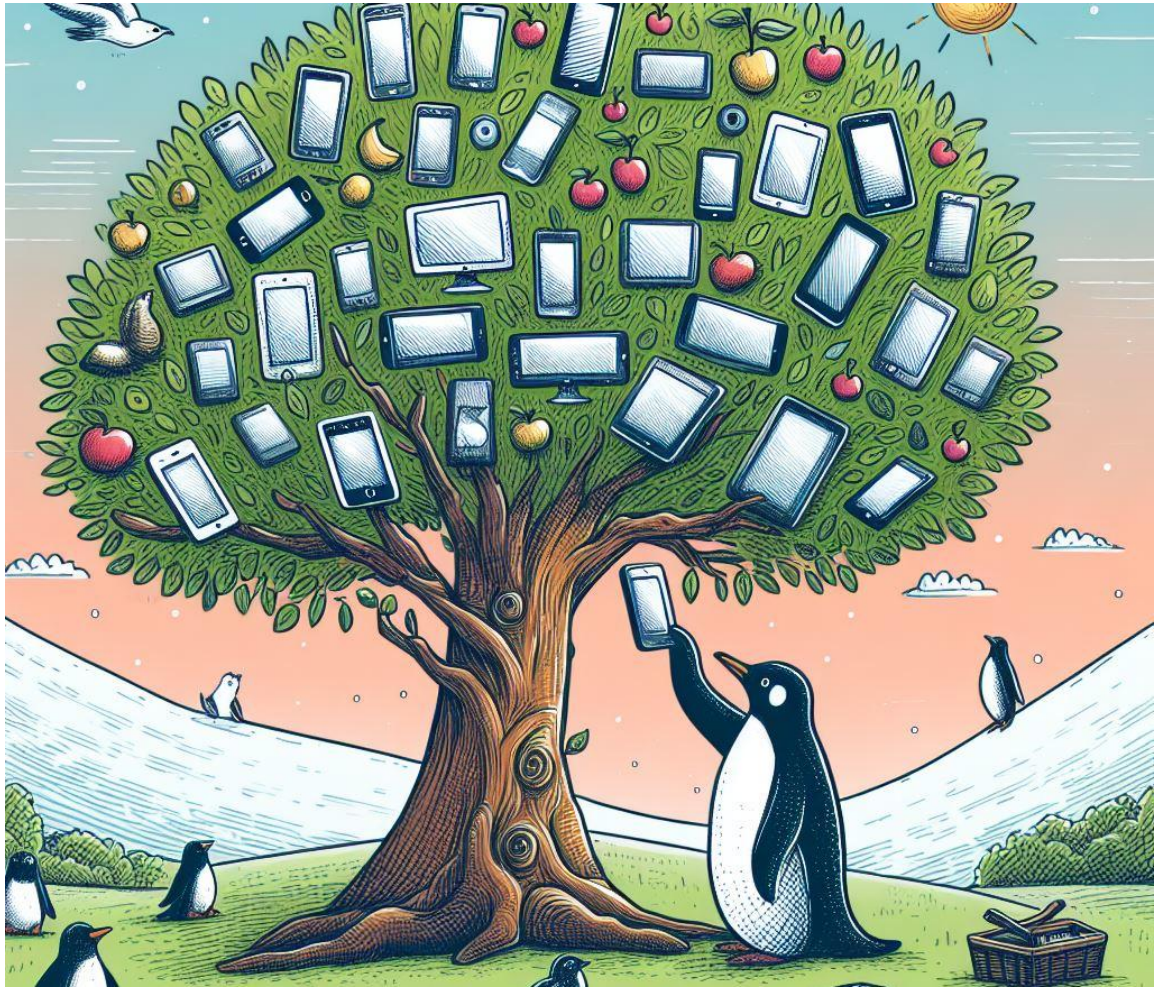
Maybe just one DTB
that developer describes
in the build command



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mkbootimg –d qrb5165-rb5.dtb

cat Image qrb5165-rb5.dtb > Image_dtb

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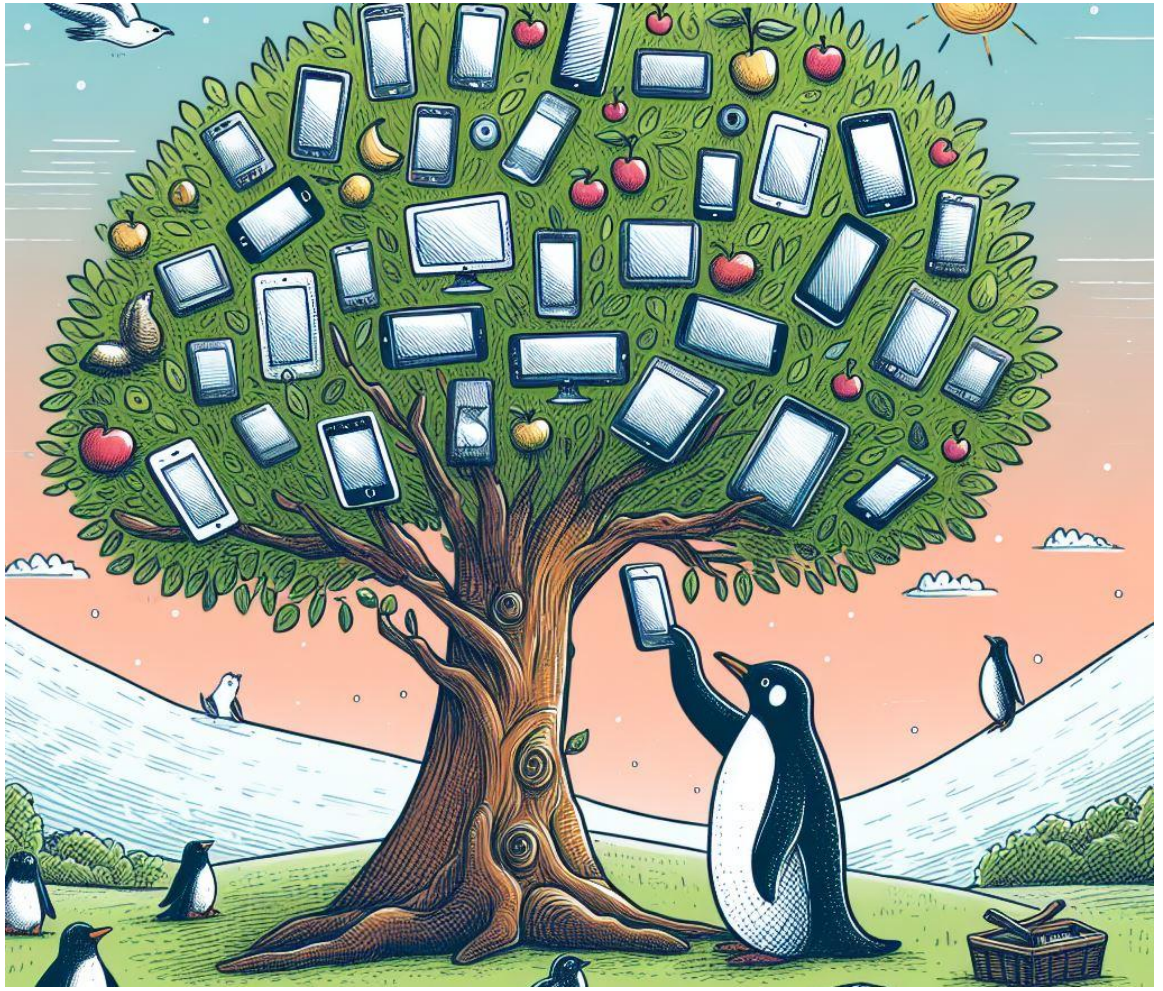
Maybe multiple DTBs get packaged and bootloader must pick



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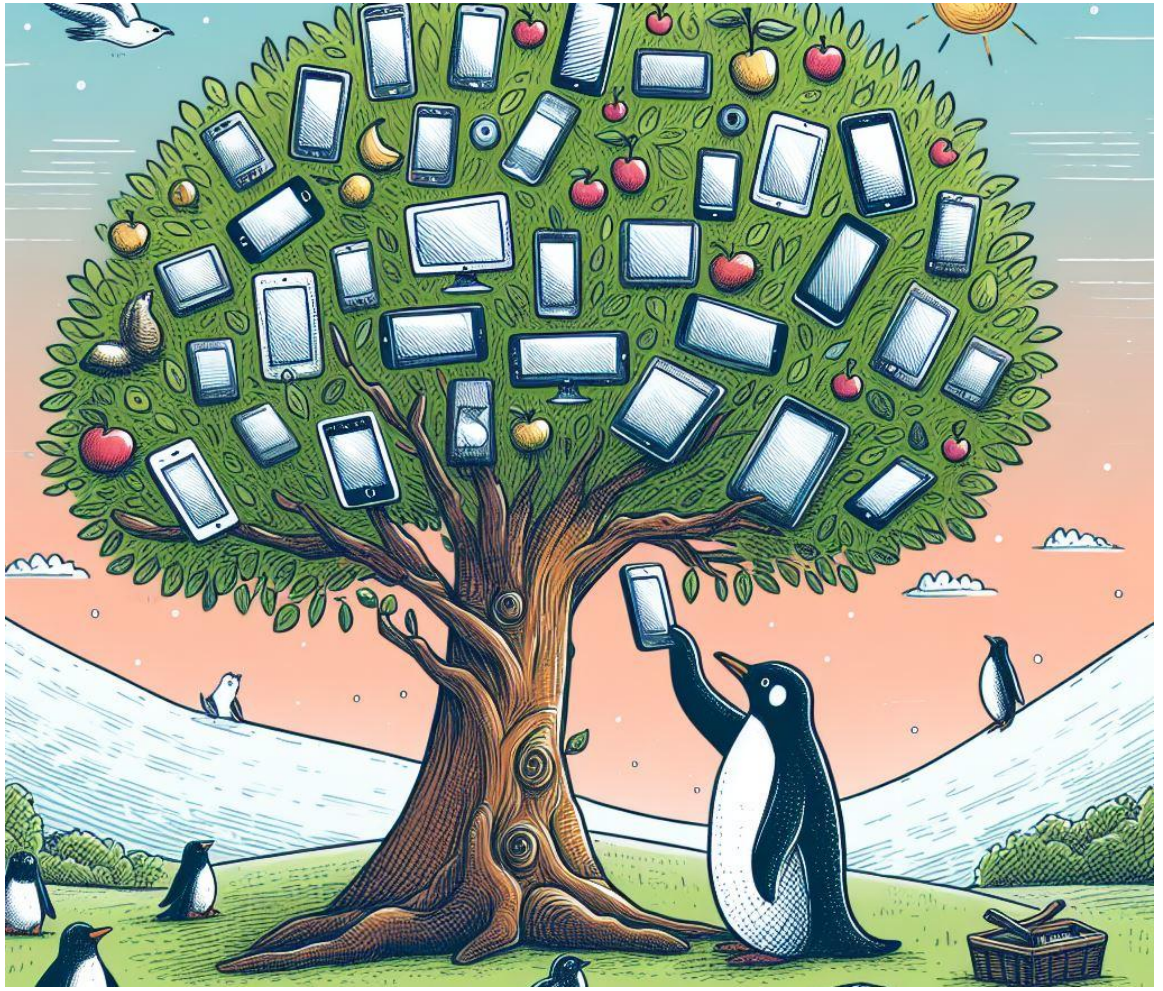
Focus of this talk is on **picking** the right DTB
not a universal packaging mechanism (future?)



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Shipping Multiple Devicetrees

- Device manufacturers want to ship one binary to variety of devices
  - OEMs: single software package that supports phone A and phone A Pro
  - Qualcomm: single software package that supports multiple reference devices
- Reduce friction when receiving a new board

Shipping Multiple Devicetrees

- Boards could have different
  - sensors
  - displays
  - coprocessor attachments
    - GPU
    - modem
    - Wi-Fi
  - PMICs

Devices from Qualcomm Technologies, Inc.

- Read SoC's HW identifier registers
- Read configuration data table (CDT)
  - Answers "which reference board is this?"
  - HDK, Robotics Dev Kit, Auto Dev Platform
  - What else attached?
    - Vision kit?
    - Display?
    - PMIC?
  - Some hardware features are encoded in board version, some are separate identifiers
- 1 software package: ~20 DTBs, ~100 overlays
- SKU is too much information
  - SKU encodes DRAM manufacturer and more
  - Demuxing SKU requires unnecessary s/w updates

Devices from Qualcomm Technologies, Inc.

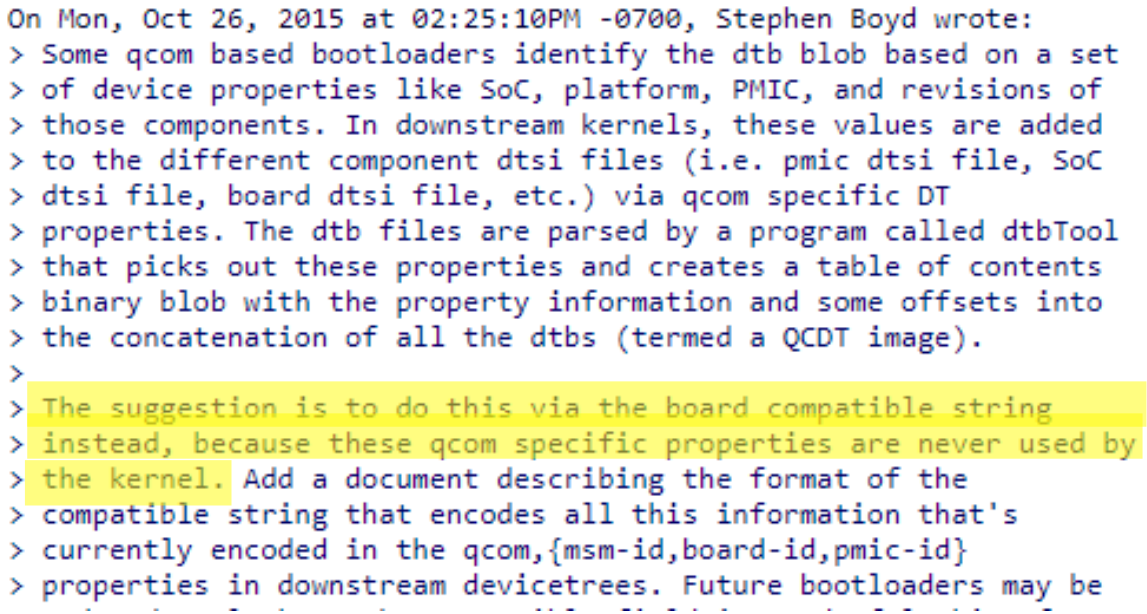
- Bootloader reads SoC HW identifiers, CDT
- Android Boot Loader [1,2] maps the values into “qcom,msm-id”, “qcom,board-id”, “qcom,pmic-id”, “qcom,oem-id”

DT property	Individual fields
qcom,msm-id	
	Chipset Id
	SoC Revision
qcom,board-id	
	Board Id
	Board Major
	Board Minor
	Subtype
	DDRtype
	BootDevice Type
qcom,pmic-id	
	Slave Id
	PMIC Id
	PMIC Major
	PMIC Minor
qcom,oem-id	
	OEM Id

[1] https://git.codelinaro.org/clo/la/abl/tianocore/edk2/-/blob/KERNEL.PLATFORM.2.0.r1-17200-kernel.0/QcomModulePkg/Library/BootLib/LocateDeviceTree.c?ref_type=tags
[2] https://lore.kernel.org/all/1710418312-6559-1-git-send-email-quic_amrianan@quicinc.com/

A decade later, we haven’t solved this

- msm-id refused because they aren’t used by the kernel [1]



```
On Mon, Oct 26, 2015 at 02:25:10PM -0700, Stephen Boyd wrote:
> Some qcom based bootloaders identify the dtb blob based on a set
> of device properties like SoC, platform, PMIC, and revisions of
> those components. In downstream kernels, these values are added
> to the different component dtsi files (i.e. pmic dtsi file, SoC
> dtsi file, board dtsi file, etc.) via qcom specific DT
> properties. The dtb files are parsed by a program called dtbTool
> that picks out these properties and creates a table of contents
> binary blob with the property information and some offsets into
> the concatenation of all the dtbs (termed a QCDT image).
>
> The suggestion is to do this via the board compatible string
> instead, because these qcom specific properties are never used by
> the kernel. Add a document describing the format of the
> compatible string that encodes all this information that's
> currently encoded in the qcom,{msm-id,board-id,pmic-id}
> properties in downstream devicetrees. Future bootloaders may be
```

[1]: https://lore.kernel.org/lkml/20151106201504.GA18276@qualcomm.com

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- msm-id refused because they aren’t used by the kernel [1]
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- msm-id refused because they aren't used by the kernel [1]
- Tried documenting/using compatible strings
  - It didn't catch on
  - Compatible strings get mind-swimmingly long
  - Requires custom parsing

```
compatible = "qcom,<SoC>(-<soc_version>)(-<foundry_id>)
              -<plat_type>(/<subtype>)(-<plat_version>)
             (-<mb>MB)(-<panel>-panel)(-boot-<boot>)(-<pmic>(-v<pmic_version>)){0-4}"
```

```
om,apq8074-v2.0-2-dragonboard/1-v0.1-512MB-panel-qHD-boot-emmc_sdc1-pm8941-v0.2-pm8909-v2.
```

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A decade later, we haven't solved this

- msm-id refused because they aren't used by the kernel [1]
- Tried documenting/using compatible strings
  - It didn't catch on
  - Compatible strings get mind-swimmingly long
  - Hard to write, hard to parse
- Tried encoding the information outside the DTB into a DT image
  - QCDT image transformed a DTB with msm-id into a DTB with some extra metadata at the header
  - No clear advantage why this is better than leaving + using msm-id

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Upstream Approaches

- Use the compatible string
  - Requires string parsing which can quickly get complex
  - Requires porting the parsing to bootloaders that needs to choose the DT
  - Used by Chromebook, Tegra (others?)
  - Compatible strings often include the SoC, but board X DTB isn't going to work on board Y, even if they have the same SoC (st,stm32mp157; qcom,sm6115)
- Put everything in the DT + bootloader picks what to enable
  - Creates contract between bootloader and devicetree

Downstream approaches

- Qualcomm: msm-id and board-id
  - Bitfield containing magic constants from board ROM
- Google Pixel: soc_id (similar approach to Qualcomm)
- AOSP: dtbo.img metadata
  - Adds optional id, revision, and u32 custom[4] for each DTB
- U-boot/FIT: Uses filename to match DTB
- Coreboot/FIT: configuration based on vendor,mainboard + board_id + sku_id

DTB Selection Feature Wishlist

- ✓Lower the effort to support new boards
- ✓Expect HW to provide more info than S/W may care about
  - ✓We probably don’t care about rev 2.1 of QCM6490 SoC
- ✓Translatable to different DTB packaging formats
- ✓Documented mechanism for how to match properties
  - ✓Consistent behavior from bootloader A to bootloader B

Current concept

Proposal; no bootloaders support this scheme today

SM8650 v2 with HDK v1.1 or HDK v1.0

```
#include <dt-bindings/arm/qcom,ids.h>

/ {
  board-id {
    qcom,soc-version = <QCOM_ID_SM8650 QCOM_SOC_REVISION(2)>;
    qcom,board-version = <QCOM_BOARD_ID(HDK, 1, 0)>,
                         <QCOM_BOARD_ID(HDK, 1, 1)>;
  };
};
```

Google Pazquel360 with LTE (newest rev)

```
/ {
  compatible = "google,pazquel-sku22", "google,pazquel-sku20",
               "qcom,sc7180";
  // Equivalent representation:
  board-id {
    google,board = "pazquel";
    google,sku = <22>, <20>;
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maybe UEFI protocol?

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Could be copied into FIT configuration

Mailing list

- RFCs: Add board-id support for multiple DT selection
  - v1: https://lore.kernel.org/all/1705749649-4708-1-git-send-email-quic_amrianan@quicinc.com/
  - v2: https://lore.kernel.org/all/1710418312-6559-1-git-send-email-quic_amrianan@quicinc.com/
- Feedback so far: get a community consensus!

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```
#include <dt-bindings/arm/qcom,ids.h>
/ {
  board-id {
    qcom,soc = <QCOM_ID_MSM8916>;
    qcom,board-version = <QCOM_BOARD_ID(HDK, 1, 0)>;
    qcom,storage = <QCOM_STORAGE_ID_EMMC>; // QCOM_STORAGE_ID_NAND
  };
};
```

Thank you

Qualcomm

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